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Author(s): Lehtinen, Auli; Kostiainen, Emma; Näykki, Piia

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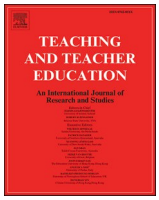
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Research paper



Co-construction of knowledge and socioemotional interaction in pre-service teachers' video-based online collaborative learning

Auli Lehtinen *, Emma Kostiainen, Piia Näykki

Department of Teacher Education, University of Jyväskylä, P.o.box 35, Fi-40014, Finland

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ABSTRACT

Building on social constructivist theory, this case study analyzed how pre-service secondary teachers co-constructed knowledge and expressed socioemotional interaction in online breakout rooms during a collaborative task. Video data was analyzed by content and interaction analysis. There was more higher-level knowledge construction than in most studies from asynchronous settings. Active listening and humor were thoroughly present. Talk about personal experiences occurred at both lower and higher levels of thinking. The teacher educator's visits to the breakout rooms and purposeful dissonance affected knowledge co-construction and socioemotional interaction. The findings will help in designing high-quality online and blended teacher education.

1. Introduction

In teacher education (TE), collaboration is essential since teachers need to both guide learners' collaborative learning and to collaboratively work as a professional learning community (García-Martínez et al., 2021; Muckenthaler, Tillmann, Weiß, & Kiel, 2020; Näykki et al., 2021). Collaborative learning has the potential to support learning as it requires participants to explain and reason their emerging understanding (Mercer & Howe, 2012; Van den Bossche et al., 2006). To reach a favorable atmosphere for learning, joint and socioemotionally positive interaction is crucial (Baker et al., 2013; Isohätälä et al., 2018; Kreijns et al., 2003). Recently, researchers have increasingly focused on how sociocognitive and socioemotional aspects of learning dynamically shape each other and teamwork outcomes (Baker et al., 2013; Hod & Katz, 2020; Isohätälä et al., 2020; Rogat & Adams-Wiggins, 2015). Learners, even in university contexts, often do not reach higher levels of knowledge construction, critical thinking, or argumentation (Isohätälä et al., 2018; Lucas et al., 2014), and collaboration can be disrupted by unregulated socioemotional challenges, such as overruling others' ideas or expertise (Näykki et al., 2014). Furthermore, although successful collaborative learning of small groups, involving negotiation and the co-construction of knowledge, has been proved beneficial for learning, studies of collaborative activity in schools show that genuine collaborative activity rarely happens (Mercer & Howe, 2012).

Online small group collaboration brings forth similar cognitive, motivational, and emotional challenges to those of face-to-face learning situations (Järvenoja & Järvelä, 2009), and, furthermore, other issues arise. Among these are reduced social and visual cues in interaction (Sherblom, 2010), physical and social distance, lack of reciprocity and a sense of community (Kreijns et al., 2003; Oittinen et al., 2022), problems related to technology and competencies in using them (Grammens et al., 2022; Oittinen et al., 2022), and fatigue associated with video-based interaction (Bailenson, 2021; Fauville et al., 2021).

Despite the growth of online education, there is limited research on synchronous video-based online learning (Mykota, 2018; Tyrväinen et al., 2021). In addition, little is known about university students' virtual teamwork processes (Ismailov & Laurier, 2021) and the teacher's role in guiding online collaborative learning. Within the field of TE, more research is needed about the affordances of online and blended modes (Perry et al., 2021). As societal changes, including continuing education, and future crises could increase the role of online education, it is important to better understand online collaborative learning and to develop pedagogical support for high-quality learning in online and hybrid TE.

The current study is among the first to use video data to explore small groups' collaboration in synchronous online breakout sessions. We focus on how pre-service teachers (PSTs) engage in knowledge co-construction and socioemotional interaction, as well as on the teacher

* Corresponding author.
E-mail addresses: auli.m.lehtinen@jyu.fi (A. Lehtinen), emma.kostiainen@jyu.fi (E. Kostiainen), piia.t.naykki@jyu.fi (P. Näykki).

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educator's role. The context is a synchronous online TE course focusing on societal issues of education and taught through Zoom sessions and breakout rooms.

2. Theoretical framework

2.1. Co-construction of knowledge in online collaborative learning

Promoting critical thinking is essential in TE (Lorencová et al., 2019). Its goals extend to learners' thinking skills and their effect at both the individual and societal levels – i.e., learners' ability to face global problems and to achieve "full expression of humanity" (Hager & Kaye, 1992, p. 27), as thinking is central to humanity. Researchers have debated over the different definitions of critical thinking (Lorencová et al., 2019). In the present study, we define critical, higher-level thinking through a social constructivist lens: as content, e.g., talk, that shows the application of cognitive and metacognitive skills through the collaborative process of negotiating meaning, where higher-level refers to the Vygotskian idea of higher mental functions, such as the use of mediating tools to have more "conscious control" over cognitive processes (Gunawardena et al., 1997, p. 409). In collaborative groups, the zone of proximal development can help mediate higher-level learning and thinking (Gunawardena et al., 1997; Smith, 1994). Social constructivists view an individual's learning as socially mediated and collaborative by nature (De Wever et al., 2010; Schrire, 2004). Knowledge is not transferred but co-constructed in an authentic, social context through interactive dialogue, questioning, and the improvement of ideas (De Wever et al., 2010; Scardamalia & Bereiter, 2003; Xie & Ke, 2011).

Thus, building on the social constructivist theory, we address higher-level thinking in TE through the five-phase interaction analysis model (IAM) by Gunawardena et al. (1997). The five phases of the *co-construction of knowledge* in the IAM are: (I) sharing and comparing of information, (II) discovering and exploring dissonance or inconsistency, (III) negotiating meaning or co-constructing knowledge, (IV) testing of proposed synthesis or co-construction, and (V) stating a summary of agreement, application of new knowledge, or metacognitive statements.

The IAM distinguishes between the kind of learning where participants only provide additional examples of ideas that are already understood, the so-called "pooling of knowledge," (lower level) as opposed to the "process of negotiation which must occur when there are substantial areas of inconsistency or disagreement to be resolved" (higher level) (Gunawardena et al., 1997, p. 413). Ultimately, the model asks whether knowledge is constructed through negotiation and whether participants create new understanding through interaction, hence, analyzing the "quality of the learning" (Gunawardena et al., 1997, p. 398). The phases have similarities with other conceptualizations of higher-level thinking, such as *critical thinking* (Gunawardena & Wilson, 2021; Newman et al., 1995), *cognitive presence* (Garrison et al., 1999), and the concepts brough forth by Mercer (2000), *accumulative* and *exploratory talk* (Onrubia & Engel, 2009).

In addition to considering its theoretical underpinnings, we selected the IAM to be used in the analysis since it has been theoretically and empirically validated in asynchronous online discussions and within instructional sciences (De Wever et al., 2006, 2010; Lucas et al., 2014) and implemented in student-centered collaborative environments (Buraphadeja & Dawson, 2008). Other analytical methods used in online discussions, for example, the community of inquiry model (Garrison et al., 1999), are more teacher-centered. The IAM has mainly been used in asynchronous online contexts, mostly within instructional science or TE (Lucas et al., 2014). With only a few exceptions, the results are similar to the ones obtained in the original study (Gunawardena et al., 1997): the proportion of higher-level, complex thinking is scant, while most discourse is at the lowest level of sharing information (Lucas et al., 2014). Overall, research is scarce on the co-construction of knowledge in synchronous video-based online learning, and, to our knowledge, the IAM has not been applied to such settings before.

2.2. Socioemotional interaction in collaborative learning

The second main concept in this study is socioemotional interaction. The role of socioemotional interaction in TE is manifold. PSTs' abilities and motivation to engage in socioemotional interaction contribute to their social and emotional competence as future professionals. Teachers' socioemotional competence is crucial as it affects teacher–student relationships, classroom management, and a healthy classroom climate, which all mediate students' social, emotional, and academic outcomes (Jennings & Greenberg, 2009). PSTs need opportunities for socioemotional growth, but studying online might deteriorate such opportunities (Carthy et al., 2022). Moreover, it is necessary for future teachers to understand and to support the socioemotional climate in collaborative learning (e.g., Isohätälä et al., 2018).

We define *socioemotional interaction* as interaction, through talk and nonverbal communication, that builds a cohesive and mutually respectful social and emotional atmosphere (Barron, 2003; Isohätälä et al., 2018), for example through the expressions of support and active listening. Socioemotional interaction affects participants' perceptions about social cohesion and psychological safety (Isohätälä et al., 2018). Strong social cohesion is positively related to student achievement (Hattie, 2009). Socioemotional interaction is also vital in supporting students' well-being, intrinsic motivation, and creativity (Boelens et al., 2017; Haerens et al., 2016).

Our focus is particularly on active listening, humor, expressing feelings, encouraging participation (Isohätälä et al., 2018; Kauffeld & Lehmann-Willenbrock, 2012), and self-disclosure (Hod et al., 2020). For example, active listening promotes positive interaction outcomes in education (McNaughton et al., 2008). Listening to the meanings of others is essential in collaboration, as highlighted already by Bakhtin (Remedios et al., 2012). Remedios et al. (2012) note that listening as a collaborative act might have been underrated due to the emphasis of learning through speaking. Active listening can be conceptualized in a variety of ways (e.g., Gordon, 2003); we focus on the expressions of attentiveness and listening through nodding and back-channeling, such as "mm" and "yeah" (Isohätälä et al., 2018). Self-disclosure, in turn, plays a significant role in relationship building (Song et al., 2019) and supports identity development (Davis, 2012). We view identities as constantly evolving and socially constructed perceptions of who one is, shaped by one's background, experiences, values, and beliefs (Davis, 2012; Ke et al., 2011). From a social constructivist perspective, learning cannot happen without opportunities to express one's identity within the social learning space (Ke et al., 2011). The potential of interaction for knowledge-building can be fostered "when opportunities encouraging students' emergent identities are embedded into the curriculum" (Delahunty et al., 2014. p. 243).

When studying collaborative learning in TE, we need to explore how cognitive, socio-relational, and affective dimensions relate to each other (Baker et al., 2013). Group research has a long history of concurrently exploring the "task function" and the "socioemotional function" (Brabender, 2010; Hod & Katz, 2020), with the former referring to appropriately pursuing the task and the latter to creating a comfortable and safe atmosphere. Baker et al. (2013) note that learning researchers have traditionally been biased toward the cognitive, at the expense of the affective. Recently, more attention has been paid to socioemotional dimensions of learning (Cress, et al., 2019; Hod & Katz, 2020; Isohätälä et al., 2018). Nevertheless, socioemotional processes are rarely examined as fine-grained sequential interaction in face-to-face groupwork (Jones et al., 2021), let alone in synchronous online interaction (Mykota, 2018). Studies analyzing affect in face-to-face collaborative learning have typically examined socioemotional phenomena for their role in serving the group's shared goals (Jones et al., 2021). We study socioemotional phenomena in relation to the "task function," but also acknowledge them as valuable in themselves.

2.3. Collaboration and interaction in video-based online learning

Social interaction and socioemotional processes are even more critical in computer-supported collaborative learning due to the features of communication, for example, chat form and restricted nonverbal information (Delahunty et al., 2014; Kreijns et al., 2003). In online environments, social and off-task communication are often neglected, and task execution is predominant (Kreijns et al., 2003). During an online lesson, it is not usually possible to exchange thoughts and feelings beforehand and afterwards (see also Grammens et al., 2022), although technologies should afford social and emotional aspects (Hod & Katz, 2020; Tarchi et al., 2022). Furthermore, turns are more likely to be minimally dialogic online (Delahunty et al., 2014). Monologic contributions can foster knowledge construction, but might discourage community building (Delahunty et al., 2014). University students have reported problems with reciprocity and connectedness, especially in the absence of video connection (Oittinen et al., 2022).

The use of web-cameras can reinforce social interaction by supporting shared attention and building a positive image of others (Castelli & Sarvary, 2021; Oitt inen et al., 2021). Video-based discussions enhance social cohesion and a positive learning climate (Grammens et al., 2022; Tyrväinen et al., 2021), reduce misunderstandings, and can make collaboration more productive (Clark et al., 2015). On the other hand, as Oittinen et al. (2021) note, the use of web-cameras might result in social anxiety and increased self-focus (Castelli & Sarvary, 2021). Recent studies have addressed the issue of "Zoom fatigue" (Bailenson, 2021; Nesher Shoshan & Wehrt, 2022), namely general, social, emotional, visual, and motivational fatigue in video-based meetings (Fauville et al., 2021). Another issue in videoconferencing is latency, which can make turn-taking frustrating and result in overlapping talks (Seuren et al., 2021).

Video-based collaboration can be facilitated using breakout sessions. A breakout session is an active learning method to engage a small group in collaboration within a larger class meeting (Lougheed et al., 2012). In video-based meetings, an *online breakout room* is a separate space where a small group can have a discussion before returning to the main meeting. They are used to enable a comfortable space for discussion (see also Reinholz et al., 2020). The instructor might be able to join the space. Some efforts have been made to study collaboration in online breakout rooms. For example, Saltz and Heckman (2020) studied how university students' team behavior changed when using structured activities in breakout rooms. Based on their observations, breakout rooms increased student-to-student interaction during and outside class. Structuring was considered useful.

2.4. Temporal perspectives to collaborative learning and the teacher's role

Collaborative learning evolves as a temporal process (Isohätälä et al., 2020; Reimann, 2009). Learning in a collaborative group means participating in a dynamic and constantly evolving social system, where everything builds on previous discussions and events, creating new opportunities for learning and participation (Mercer, 2008; Näykki et al., 2017). This is similar to the overall cumulative quality of the educational processes (Mercer, 2008; Reiman, 2009). The constant moment-by-moment fluctuations of, for example, emotions can play a key role in how learners participate and how they succeed in collaborative learning situations (Isohätälä et al., 2020; Näykki et al., 2014). Because the variables involved in collaborative learning interact in very complex ways, there has been a shift toward a more process-oriented approach, which seeks to identify features of interaction that are critical to learning and cognitive change (Mercer & Howe, 2012). Lucas et al. (2014) identify a research gap in visualizing interaction processes related to knowledge co-construction to provide more holistic insights into collaborative activity.

In online learning processes, the teacher's role is essential. However, there is a lack of studies exploring the teacher's role in guiding collaborative learning in video-based online sessions. According to Grammens et al. (2022), teachers' competences in synchronous online learning are relatively unidentified. In their systematic review, they found five teacher roles in synchronous settings: instructional, technical, social, managerial, and communicational roles. Contrary to asynchronous text-based interaction, teachers can intervene "ad hoc," providing more information and guiding the process. Important competencies include stimulating active learning, for example, using breakout rooms, facilitating social interaction, and creating a learning community (Grammens et al., 2022).

3. Purpose of the study and research questions

This study addresses several gaps in the research area. It is necessary to better understand how sociocognitive and socioemotional aspects of learning shape each other in technology-enhanced environments (Hod & Katz, 2020) and how online and hybrid modes afford learning in teacher education (Perry et al., 2021). More research is needed on video-based teaching (Oittinen et al., 2022; Tyrväinen et al., 2021), on knowledge construction in emerging learning environments (Lucas et al., 2014), and on critical thinking in university contexts (Gunawardena & Wilson, 2021). Finally, little is known on how teachers enact various roles in synchronous video-based learning (Grammens et al., 2022).

The aim of this study is to analyze the quality of knowledge co-construction and socioemotional interaction in a synchronous online TE course, specifically in Zoom breakout rooms. The research questions are.

1. What is the quality of co-construction of knowledge in pre-service teachers' breakout room discussions during a collaborative task?
2. What kind of socioemotional interaction do pre-service teachers express in breakout room discussions during a collaborative task?
3. What characterizes the temporal processes of knowledge co-construction and socioemotional interaction, and how does the teacher educator's visit to the breakout room influence these processes?

4. Methods

We implemented a naturalistic case study (Stake, 1995) to gain in-depth understanding of knowledge co-construction activities and socioemotional interaction within online breakout rooms. A natural design within a real-life setting can be considered ecologically valid (Lipponen et al., 2003).

4.1. Context

Data were gathered from January to April 2022 at a Finnish university during an online TE course that took place in Zoom due to COVID-19 restrictions. The course was part of pre-service secondary teachers' compulsory studies in education (60 EC TS), the focus in this course being on societal issues of education. In Finland, prospective secondary teachers from different disciplines usually become teachers for grades 7 to 9 (ages 13–16) and for upper secondary school or vocational school (ages 16–19), teaching one to three school subjects. This course was part of the PSTs' first academic year. The course design aimed at promoting collaboration in several ways, as PSTs worked in mixed subject groups and as course tasks involved small group collaboration. Students had worked in the same mixed subject groups during the fall of 2021, but in a face-to-face setting. The sudden changes to COVID-19 restrictions just before the start of the course furthered our interest in looking at online teaching during turbulent times, as the pandemic had influenced teaching practices for almost two years.

The main task in the course dealt with teachers as transformative agents in society. In small groups, students chose one global megatrend (e.g., Naughtin et al., 2022), such as digitalization, social and cultural

diversity, or consumer behavior. They were instructed to collaboratively answer the questions while working in small groups in Zoom breakout rooms: What makes this megatrend interesting in terms of education? How does it challenge educational traditions? How does it appear from the perspective of different school subjects? What kind of change would you like to bring to schools as transformative teachers? Based on discussions and reading of relevant articles, students prepared a presentation where the emphasis was on generating discussion among peers.

4.2. Data collection

Data were collected using video recording. The first author observed the Zoom main sessions in real time but did not enter the breakout rooms. Instead, the participants were asked to record them and send the videos to the first author after class. Participation was voluntary, and PSTs filled in a written consent form to confirm having received sufficient information about the research. Participants acknowledged that they were free to withdraw their participation at any time and without consequence.

We analyzed the processes of two small groups (n = 4 and n = 5 PSTs and one teacher educator). Participants were given pseudonyms, and their majors and ages are described in Table 1. Group1 worked on the megatrend "consumer behavior" and Group2 on the megatrend "digitalization." The durations of the analyzed breakout rooms were 33 and 54 min for Group1 and 33 and 47 min for Group2, yielding altogether 2 h 47 min of data. These groups worked during two Zoom sessions held on consecutive weeks (Fig. 1), discussing and planning the main task. The teacher educator visited each of the breakout rooms, with the visits varying from 5.5 to 10 min.

We chose the case groups and the situations after the first author broadly examined all the videos and observation notes from the main sessions and breakout rooms (12 h 15 min). The analyzed situations were chosen for several reasons: (a) they enabled analyzing longer processes of planning and meaning-making, as opposed to short breakout rooms; (b) the complete process was available for these two small groups; (c) the task was collaborative, open, student-centered, and process-oriented; and (d) themes were challenging and relevant regarding global megatrends.

Robin from Group2 dropped out of the course during the process and was present only during the first group situation. Robin did not have a web-camera on and contributed little (5.9% of the duration of the video). Dropping out is common for online learning courses (Strauβ & Rummel, 2021). Additionally, Laura from Group1 was present only during the second session.

4.3. Data analysis

We used content and interaction analysis in this study to demonstrate dynamic patterns of interaction and for making students' online learning visible (De Wever et al., 2006; Derry et al., 2010; Xie & Ke, 2011). The aim was not only to count the number of codings but to reveal phenomena below the surface (De Wever et al., 2007; Rourke et al., 2001).

Table 1
Participants.

Group1, consumer behavior megatrend		
Pseudonym	Major	Age in Jan 2022
Elias	Mathematics	20
Emma	History	not available
Laura	Educational technology	19
Nea	Finnish language and literature	20
Group2, digitalization megatrend		
Pseudonym	Major	Age in Jan 2022
Ida	English	20
Ella	Chemistry	not available
Sara	Mathematics	20
Sofia	English	not available
Robin (dropped out during the process)		

The small group was treated as the primary unit of analysis (Barron, 2003), along with individual contributions. Thus, our perspective is social constructivist while also considering individuals' actions (Xie & Ke, 2011). Individual processes are necessary but not sufficient when addressing collaboration (Arvaja et al., 2007). We argue that exploring both the small group and individual levels enriches the analyses. We coded the teacher educator's contributions with the same categories but treated them separately due to the teacher's different role.

The first author conducted the video analysis using qualitative data analysis software ATLAS. ti 22. Coding was done directly on the timeline of the video. The transcribe feature of Microsoft Word was used to automatically generate transcripts, which were read only momentarily alongside the video data to help return to specific moments.

4.3.1. Unit of analysis and video analysis process

Following Isohätälä et al. (2018, 2020), we selected 30-s segments of video data as units of analysis. Other similar studies have used 5-min segments (Sinha et al., 2015; Sullivan & Wilson, 2015). The segmented timeline has been considered a manageable framework for closely analyzing video data (Sullivan & Wilson, 2015). We chose 30 s since it is short enough to analyze small groupwork as fine-grained sequential interactions and long enough to observe different aspects of social interaction converging in the same episodes (Isohätälä et al., 2020). A total of 333 episodes of 30 s were analyzed.

De Wever et al. (2006) stress the importance of setting the granularity of content analysis by the choice of unit of analysis and linking the choice to the theoretical framework. The 30-s segments enabled us to analyze the flow of interaction and meaning-making processes, as phases of interaction are rarely clear-cut and as transcripts might not give justice to their complexity. This choice allowed exploring nonverbal communication as thoroughly embedded in talk (Jones et al., 2021; Richmond et al., 2012). Additionally, the same segment could be coded to various categories. Building on a social constructivist approach, such decisions are coherent with the Vygotskian idea that analysis should examine the activity as a whole and not isolated elements (Hull & Saxon, 2009; Moll, 1990). Thus, for example, the analysis of knowledge co-construction required profoundly examining the whole context, and gradual changes in collaborative thinking could be illustrated. Turn-by-turn coding within the 30-s segments was the basis for the analysis. This is explained in more detail in Section 4.3.2.

The analysis process was iterative. Through several cycles of viewing the video data and literature review, the main- and sub-categories were constructed. We used theory-driven categories but chose and modified them inductively. In computer-mediated communication research, the use and further validation of existing codes has been considered important, as it enhances replicability and validity (De Wever et al., 2006; Marra et al., 2004). The use of existing codes can be criticized for limiting the "analyst's sensitivity for what actually happens" (Mercer, 2004, p. 142). We considered this by not predefining codes before the analysis but by inductively choosing and modifying them in dialogue with data and literature.

4.3.2. Categories for the co-construction of knowledge

The co-construction of knowledge was analyzed using the IAM categories (Gunawardena et al., 1997), namely (I) sharing/comparing of information, (II) dissonance, (III) negotiation/co-construction, (IV) testing tentative constructions, and (V) agreement statement/application. First, levels of co-construction of knowledge were coded on an individual level, yielding altogether 654 codings.

When several participants spoke in the same segment, we coded one level for each of them. If a participant's turn went on for several 30-s segments, each of the segments were coded, but only with one level of co-construction of knowledge. In this way, the analysis unit resembled a

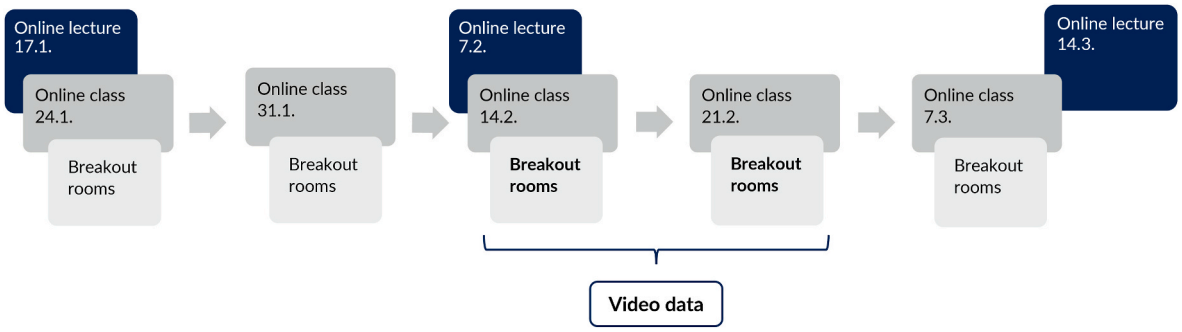


Fig. 1. The course design.

complete message used in asynchronous settings (De Wever et al., 2010; Lucas et al., 2014). Following De Wever et al. (2007), when the turn "comprises elements of two different levels of knowledge construction, the highest level was assigned" (p. 439). Thus, for example, when a student's turn lasted for 1 min 17 s, extended to three segments, and the student firstly expressed ideas on level I and then on level II, all three segments were coded to level II. This decision was made since often the meaning of the turn could be interpreted only by analyzing all the segments in which the participant spoke. Turns were considered separate when another participant contributed something in between them and not only reacted through back-channeling. All verbal contributions were coded according to the levels of knowledge construction, except for the back-channeling turns. At the group level, we assigned the highest level of individual codings to the segment.

4.3.3. *Categories for socioemotional interaction*

We explored socioemotional interaction with the following categories: active listening (Isohätälä et al., 2018), laughter or humor (Isohätälä et al., 2018; Kauffeld & Lehmann-Willenbrock, 2012), life outside (Hod et al., 2020), expressing feelings (Hod et al., 2020; Kauffeld & Lehmann-Willenbrock, 2012), and encouraging participation (Kauffeld & Lehmann-Willenbrock, 2012). We chose and modified the codes and their definitions in the process, vis-à-vis with the analysis cycles. The individual-level analysis of socioemotional interaction yielded 1309 codings.

We firstly coded socioemotional interaction at an individual level (e.g., laughter or humor/Laura), and codes were not mutually exclusive. This means that the same 30-s segment could receive several socioemotional codes, for instance nonverbal active listening and laughter or humor. Life outside and expressing feelings were coded to the segments in which they were explicitly mentioned.

Nonverbal data offer unique information and are less often analyzed as embedded in talk (Jones et al., 2021). In this study, we analyzed nodding, smiling, and laughter. The way participants used or did not use web-cameras formed an integral part of nonverbal communication in breakout rooms.

At the small group level, active listening and laughter or humor were coded for the segment when 50% or more of the PSTs expressed them, because they are elementarily reciprocal. The rest of the socioemotional categories were assigned at the group level when at least one PST expressed them. Table 2 shows both the individual- and group-level descriptions of categories. Grounded data examples for each code (individual level) can be found in Table 3.

Table 2
Categories of co-construction of knowledge and socioemotional interaction.

Category	Sub-codes	Individual-level description Participant …	Group-level description
Co-construction of knowledge	I Sharing/comparing of information	(see full description in Gunawardena et al., 1997) states observations or opinions, provides additional examples, or asks for clarifications	Highest individually coded level was assigned for the whole segment
	II. Dissonance	identifies cognitive dissonance, inconsistency, or disagreement; or restates one's position and introduces arguments (based on, etc., formal data, literature, or experience)	
	III. Negotiation/co-construction	proposes new co-constructions that embody compromise, or negotiates the meaning of concepts or the value of different arguments	
	IV. Testing tentative constructions	tests the newly constructed knowledge against personal understanding or other resources (e.g., literature)	
	V. Agreement statement/ application	summarizes agreement, applies the newly constructed knowledge, or expresses metacognitive statements	
Active listening	Verbal	signals listening by back-channeling turns, e.g., "mmm," "yeah" (not applicable when participant directly starts their turn, e.g., "yeah, yeah, I think …")	The segment was coded when 50% or more of the pre-service teachers expressed active listening (any sub-code)
	Nonverbal	signals listening by nodding	
	Nonverbal & verbal	signals listening by nodding and back-channeling turns	
Laughter/humor		shows amusement by laughing or smiling amusedly when something funny happens or is said; humor is inoffensive	The segment was coded when 50% or more of the pre-service teachers expressed laughter/humor
Life outside	On-task	shares or discloses details about one's life outside the community that are related to, e.g., experiences from school/education, or to other experiences; talk is related to task	The segment was coded when at least one pre-service teacher talked about life outside (any sub-code)
	Off-task	shares or discloses details about one's life outside the community; talk is not related to task	
Encouraging participation		addresses quiet participants, e.g., "What do you think, Anne?" "How about you?"	The segment was coded when at least one pre-service teacher encouraged participation
Expressing feelings		mentions positive, negative, or mixed feelings, e.g., "I'm so happy to see you," "I was afraid we would not be able to do this"	The segment was coded when at least one pre-service teacher expressed feelings

Table 3
Coding examples.

Code	Example
Co-construction of knowledge	
I. Sharing/comparing information	Emma: "how could it be, like, taken into the school world in an explicit way?" (I) Nea: "well, as a student of the Finnish language, it comes to my mind, that for example, some texts that touch the topic can be addressed in language arts, in such a way that it is not the actual theme, but it appears in it" (I); Nea: "before the next time we work on this, could everyone please make something like a synthesizing, like a mind map or something like that, so that there would be a basis from which to start" (I)
II. Dissonance	Emma: [reading instructions] "how does your megatrend challenge school traditions?" (I) Nea: "what is meant by school traditions?" (I) Emma: [reading instructions] "ways of thinking, procedures, background assumptions" (I) Nea: "well, I think that maybe it isn't exactly the case that this only applies to school, but rather this is more broadly, like, sort of a societal background assumption, this consumer behavior" (II, Identifying and stating areas of disagreement); Emma: "then when you think about that as well, what like, one should personally be like, it feels wrong, in a way, that students are forced to do things that one doesn't even personally do [as a teacher or adult]" (II, Identifying and stating areas of disagreement)
III. Negotiation/co-construction	Emma: "but that was actually a good point, that like, how the individual versus like the society, so, how could that kind of questioning be brough up in schools, like who's responsibility [laughter] it really is" (III, Negotiation of the relative weight to be assigned to types of argument; Identification of areas of agreement or overlap among conflicting concepts); Nea: "it came to my mind from that coffee cup example [by the teacher educator], that at school you could like, or when [the teacher educator] said one should like, or should that coffee cup be made from some other material which could be more easily, like, reused, recycled, etc., so could schools, in a way, encourage the development of new kinds of innovations which would then be more sustainable, and that kind of thing, because they don't just appear on their own, those more sustainable alternatives, could the school be such an environment that would, like, encourage the adults of the future to develop more ecological alternatives, and how could it be done" (III, Proposal and negotiation of new statements embodying compromise, co-construction; Proposal of integrating or accommodating metaphors or analogies)
IV. Testing tentative constructions	Nea: "but, like, could it be that consumerism has sort of like become a norm in our society?" (III) Laura: "yeah exactly, yeah, that was what I sort of tried to point out [Nea laughs], but just like, that it has become a norm that one has to" (I) Nea: "okay, yeah" [laughter] Laura: "and of course, from society's point of view, you can think about all that, in a way, where does the consumer behavior sort of like drive us, so like climate change affects society awfully lot, it affects the individual level, it affects the school level, but it also affects the societal level, if you think about something like taxation or something else like that, also bigger things" (IV, Testing the proposed synthesis against "received fact" as shared by the participants and/or their culture)
V. Agreement statement/ application	Teacher educator: "what kind of ideas do you have on how it [ecological perspectives related consumer behavior] could be influenced?" Emma: "well didn't we think, sort of like, well, either that there would be a specific school subject or that it would be, like, brought along into every school subject, in some way, that kind of ecological thinking, or what is it, ecological civilization [laughter]" (V, Summarization of agreement(s)); Nea: "[the teacher educator] had some really good points, but somehow I feel like they were even, like, extra broad and somehow they completely emptied my own thoughts [laughing], and that individual level is indeed much easier, so when you start thinking about the societal level, and what can be changed there and how, well, it's like, it really, really, feels distant and somehow difficult" (V, Metacognitive statements by the participants illustrating their understanding that their knowledge or ways of thinking (cognitive schema) have changed as a result of the conference interaction)
Active listening	
Verbal	"mmm"; "yeah"
Nonverbal	nodding
Verbal & nonverbal	"yeah" and nodding
Laughter/humor	
	Nea: "for instance, I terribly like buying things from flea markets or buying second hand from [an online secondhand service] and then, for example, my mom is always, like, why is it sold and is it broken and is there an infection or something else" [mimicking one's mother's talk and laughing]; smiling when something funny is said
Encouraging participation	
	Nea: "okay, how about the rest of you?"
Expressing feelings	
	Nea: "so nice that this group was formed, because I was afraid it wouldn't" [laughing]
Life outside	
On-task	Elias: "like some kind of, say, thematic days or such, they would be like, at least it came to my mind that we have had those in school"
Off-task	N/A

Table 4
Reliability of group level analysis (86 min).

Category	Krippendorf's alpha (n = 173)	Percent agreement
Co-construction of knowledge	.53	66.5%
Active listening	.77	88.4%
Laughter/humor	.80	91.3%
Life outside	.73	87.9%
Expressing feelings	.70	87.9%
Encouraging participation	.91	99.4%
Reliability of individual level analysis (33 min)		
Category	Krippendorf's alpha	Percent agreement
Co-construction of knowledge	.58 (n = 133)	71.2%
Active listening (with sub-codes)	.66 (n = 158)	77.3%

4.3.4. Reliability

The first author and a research assistant conducted an interrater reliability check at both the individual and group level coding (approximately 20% and 50% of the data, respectively). Before coding, the research assistant received 4 h of face-to-face training and read relevant articles (Gunawardena et al., 1997; Isohätälä et al., 2018). First, having coded one video, disagreements were fully resolved by discussion. The analysis scheme was elaborated, and more grounded examples were provided. Next, the videos were coded independently. After the independent coding, we identified a part where one particularly long turn was interpreted differently. Disagreements of knowledge construction (n = 11) were resolved. Then, we calculated inter-rater reliability at both the individual and group levels (Table 4). At the individual level, interrater reliability values were calculated for the categories of knowledge co-construction and active listening, as these categories are presented at the individual level in the results.

Krippendorf's alpha values for different categories were situated between .53 and .91, which represent fair to good agreement (De Wever et al., 2010; Neuendorf, 2002). Reliability of co-construction of knowledge was similar to earlier studies (De Wever et al., 2007, 2010). It does not deal with surface content but with hidden facets of social cognition (Rourke et al., 2001); thus, it was presumable its reliability would not be equally high. After the reliability check, the first author compared the codings and revised them where it seemed justifiable before coding the rest of the data (47 min).

5. Results

The results are presented according to the research questions. Firstly, we explore how PSTs engaged in knowledge co-construction (Section 5.1) and socioemotional interaction (Section 5.2) in the breakout rooms. In Section 5.3, we illustrate the temporal processes of knowledge co-construction and socioemotional interaction and the role of the teacher educator's visits. The groups are referred to as Group1 (consumer behavior) and Group2 (digitalization).

5.1. What is the quality of co-construction of knowledge in pre-service teachers' breakout room discussions during a collaborative task?

Four breakout room situations, comprising 333 segments of 30 s, were analyzed. First, we present the results at the small group level, and then at the individual level. Knowledge co-construction analysis showed that for both groups, most of the talk was at level I of sharing information or opinions, and level III of negotiation or co-construction (Table 5). A relatively small percentage of talk was at level II and at the highest levels IV and V.

During the first session, Group1 discussed more on the level III of negotiation and co-construction, their talk focusing often on defining the issue on conceptual level, whereas Group2's talk was less on the level of negotiation, and they focused more on sharing experiences (level I). In the second session, differences can be found most notably on level I. Group1 reached the higher levels more often, while Group2's talk was on the lowest level of sharing information for approximately half of the time. Nevertheless, for Group2, the proportion of level III increased when compared to their first session.

Focusing on the individual level, we discovered that the PSTs differed in their ways of contributing to the co-construction of knowledge, and this is visualized in Fig. 2. Contributions by two PSTs (Laura and Robin), one from each group, are not visualized in the figure since they were present only in one session.

Individual differences can be observed mostly in the overall amount of knowledge construction and in the extent to which participants engaged in dissonance (II) or higher levels of knowledge construction (III, IV, and V). Among the seven PSTs, Elias was the only one not having a web-camera on. Elias contributed notably less compared to the rest of the small group. The contributions by Elias and Ida were quite similar since both negotiated or co-constructed meaning (III) only in three or four 30-s segments. They did not engage in discussion on the higher levels, IV or V. Also Robin, who was present only in the first session, did not have a web-camera on and contributed very little.

Table 5
Co-construction of knowledge at the group level (% of time).

	Group1 Video 1 33 min	Group2 Video 1 33 min	Group1 Video 2 53 min	Group2 Video 2 47 min
I. Sharing/comparing	46.6%	57.4%	37.6%	51.1%
II. Dissonance	6.9%	6.6%	8.9%	6.8%
III. Negotiation/co-construction	37.9%	24.6%	34.7%	31.8%
IV. Testing tentative constructions	0%	6.6%	9.9%	8.0%
V. Agreement/application	8.6%	4.9%	8.9%	2.3%

5.2. What kind of socioemotional interaction do the pre-service teachers express in breakout room discussions during a collaborative task?

We present results firstly at the small group level, and then at the individual level. The proportions of socioemotional interaction at the group level are presented in Table 6.

Active listening was the most frequently expressed socioemotional aspect. Also, laughter and humor were frequently expressed in all sessions. The PSTs' first planning sessions differed in the extent to which they expressed laughter or humor, engaged in talk related to experiences from life outside (mostly about school), and expressed feelings. During the first session, Group2 shared experiences from life outside during more than half of the session time, as opposed to 16.7% of Group1. Interestingly, we observed no off-task sharing of personal life. Group1 expressed more laughter or humor, whereas Group2 expressed considerably more feelings. Participation was encouraged rarely or not at all. In the second planning sessions, socioemotional processes were more similar between the small groups.

At the individual level, the PSTs differed in their ways of contributing to socioemotional interaction. This is visualized through the category of active listening (Fig. 3) since it was the most frequently expressed socioemotional facet. Contributions by two PSTs are not visualized in the figure since they were present only in one session.

There were noticeable individual differences. For instance, Elias, who did not have a web-camera on and participated less in knowledge construction (see Section 5.1), also expressed less active listening. However, Elias did express verbal back-channeling though the use of the microphone. Overall, Elias expressed more active listening compared to another less active participant, Ida. Ida did have a web-camera on but used scarcely its affordances for nonverbal active listening. Emma differed from most PSTs by mostly expressing listening through verbal back-channeling.

5.3. What characterizes the temporal processes of knowledge co-construction and socioemotional interaction, and how does the teacher educator's visit influence these processes?

Both the knowledge construction and socioemotional interaction as temporally unfolding processes are presented in Figs. 4–7. The analytical focus is on the small group level. The occasions where the highest level of knowledge construction was by the teacher educator are marked with T. We use the pseudonym Jody for the teacher educator. We did not mark Jody's contributions on socioemotional interaction in the figures. First, we address the main findings of temporal processes in general, and then, we present an illustrative case example of how Jody's visit affected knowledge construction and the socioemotional climate (Section 5.3.2) (see Fig. 8).

5.3.1. Temporal processes

The temporal processes of knowledge construction and socioemotional interaction differed between the small groups. The main findings about knowledge co-construction processes were: (1) the teacher educator affected knowledge co-construction processes by expressing dissonance and asking for syntheses (2) sharing of personal experiences (life outside) occurred simultaneously at both lower and higher levels of knowledge co-construction, and (3) the use of multiple guiding questions helped PSTs in achieving higher levels of knowledge construction. The main results concerning socioemotional processes were: (1) active listening occurred simultaneously with both experiential and conceptual or synthetizing talk, but indications of active listening and laughter or humor diminished as the teacher educator expressed dissonance; (2) laughter or humor was thoroughly present in many phases, both in the teacher educator's and PSTs' talk, and (3) many aspects of socioemotional interaction were present throughout the processes. Next, we further explain these results. Findings about the teacher educator's role are presented in Section 5.3.2.

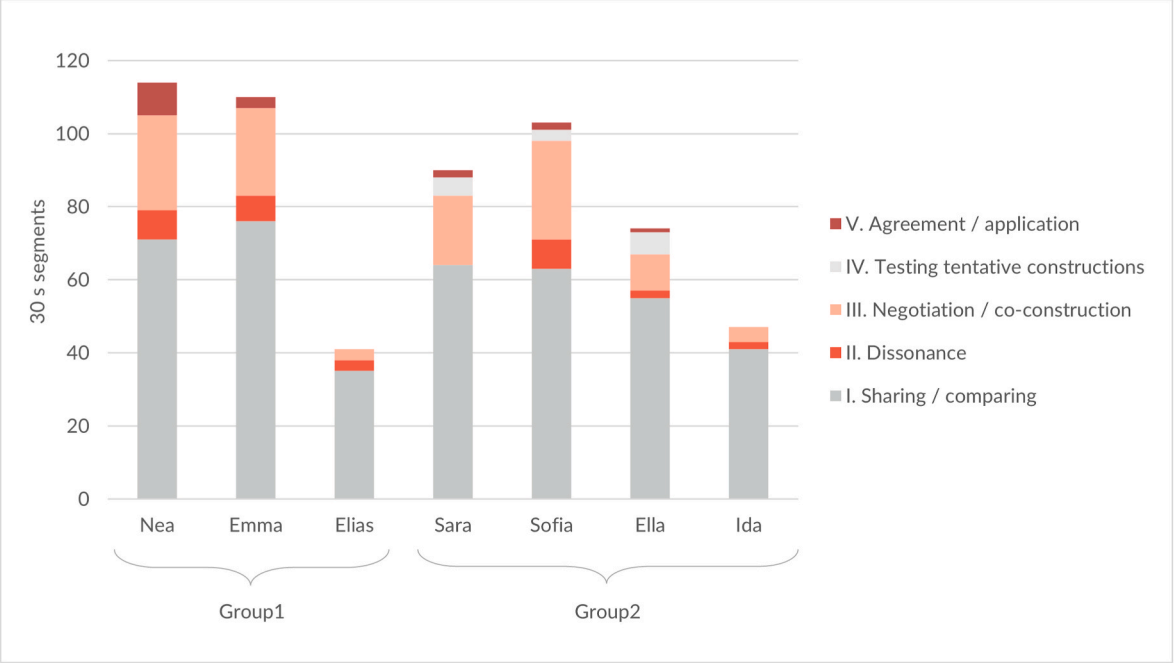


Fig. 2. Co-construction of knowledge in both sessions, Group1 (total 174 segments) and Group2 (total 159 segments).

Table 6
Socioemotional interaction at the group level (% of time).

	Group1 Video 1 33 min	Group2 Video 1 33 min	Group1 Video 2 53 min	Group2 Video 2 47 min
Active listening	57.6%	46.2%	60.2%	70.2%
Laughter/humor	40.9%	23.1%	37.0%	43.6%
Life outside	16.7%	53.8%	25.9%	18.1%
Expressing feelings	15.2%	46.2%	25.0%	20.2%
Encouraging participation	0%	4.6%	0.9%	0%

In Section 5.1, we showed that the overall quality of knowledge construction was of a lower level for Group2. This is also evident in the temporal visualizations. During the first sessions, Group2 reached higher levels (III–V) only after the visit by the teacher educator, whereas Group1's interaction fluctuated constantly between lower and higher levels. During the second sessions, Group2 reached the highest level only once (Fig. 7), while Group1 did so in six separate occasions (Fig. 6). When viewing video data alongside these figures, we observed that successful use of the guiding questions helped Group2 define their perspectives and reach higher levels of knowledge construction (Fig. 5 between 25 and 30 min).

In their first session (Fig. 5), Group2 shared more feelings and experiences related to life outside than Group1. In that session, talk related

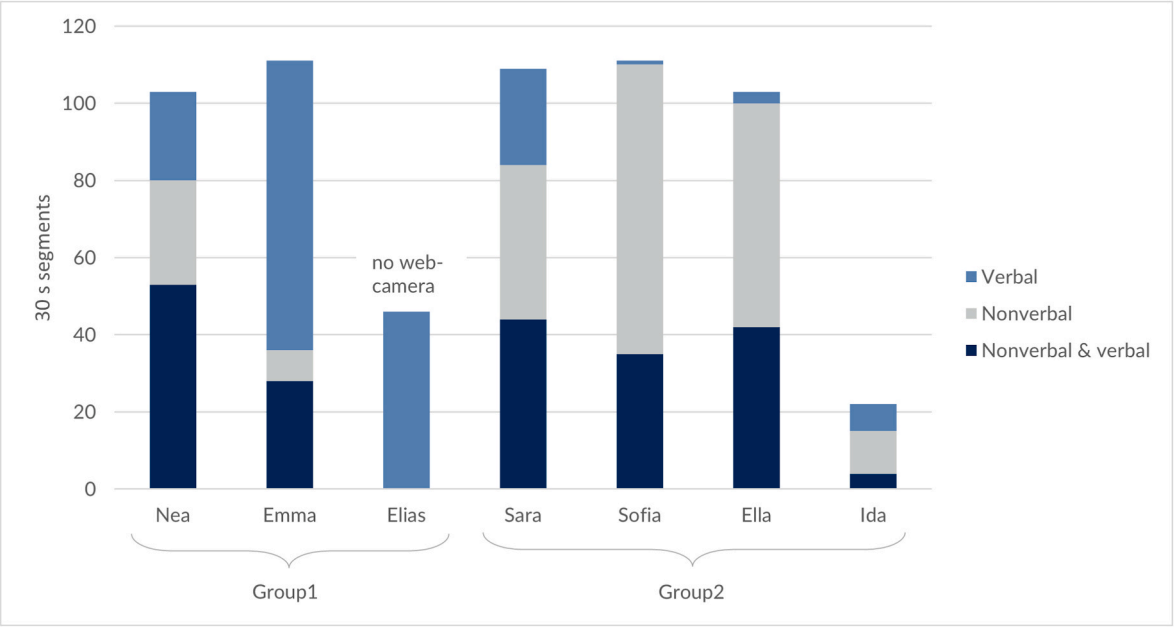


Fig. 3. Active listening in both sessions, Group1 (total 174 segments) and Group2 (total 159 segments).

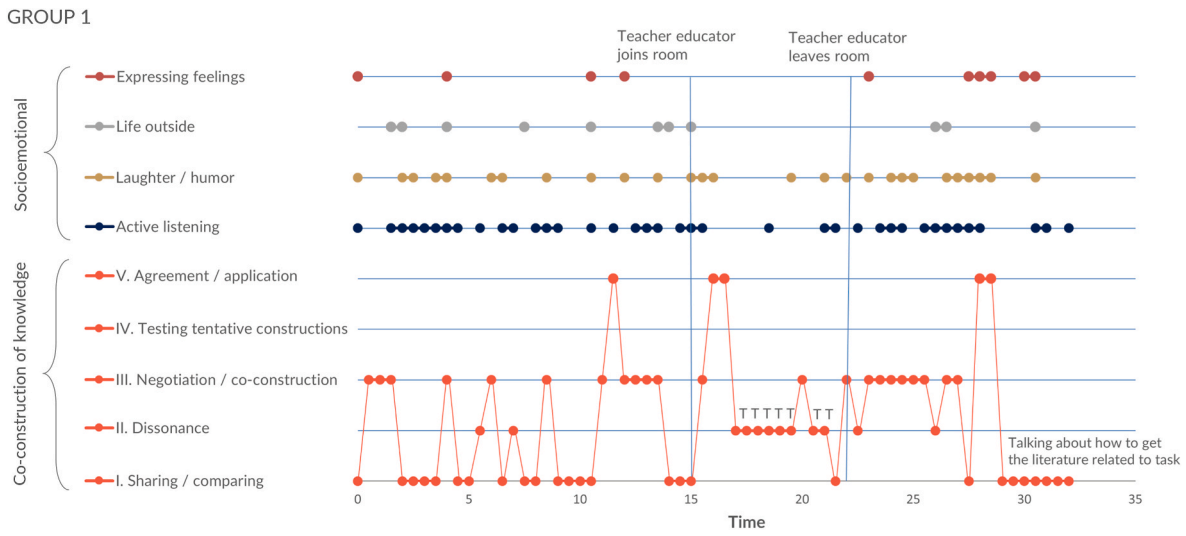


Fig. 4. Group1, first session.

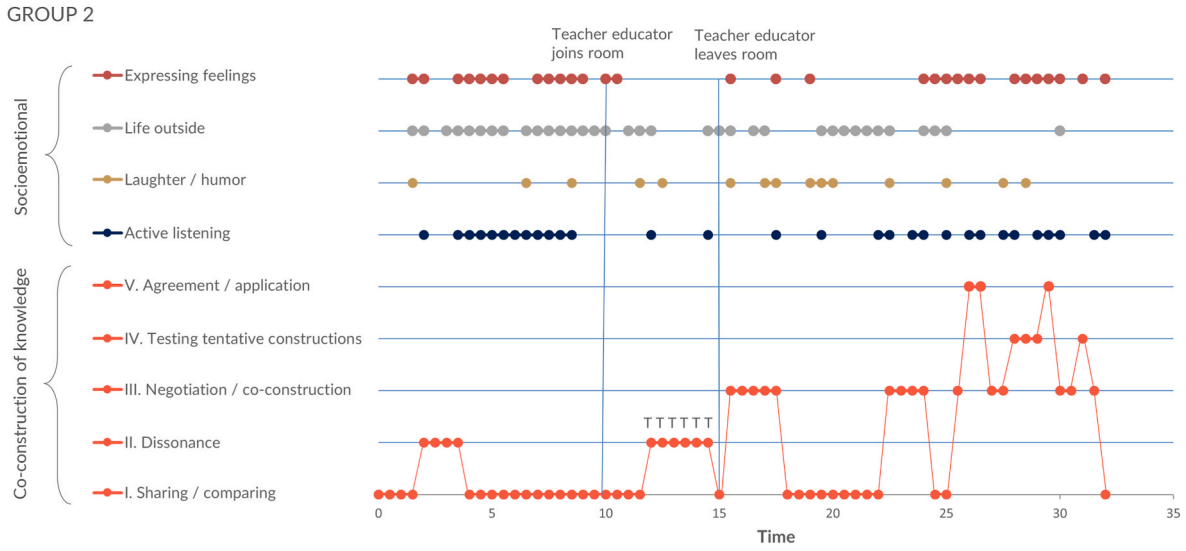


Fig. 5. Group2, first session.

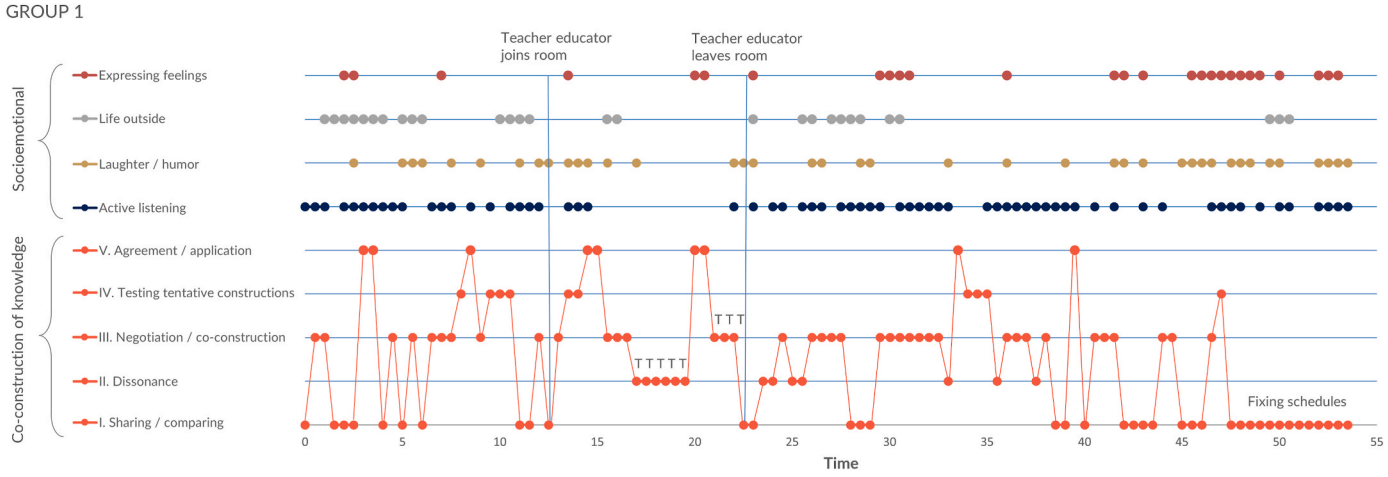


Fig. 6. Group1, second session.

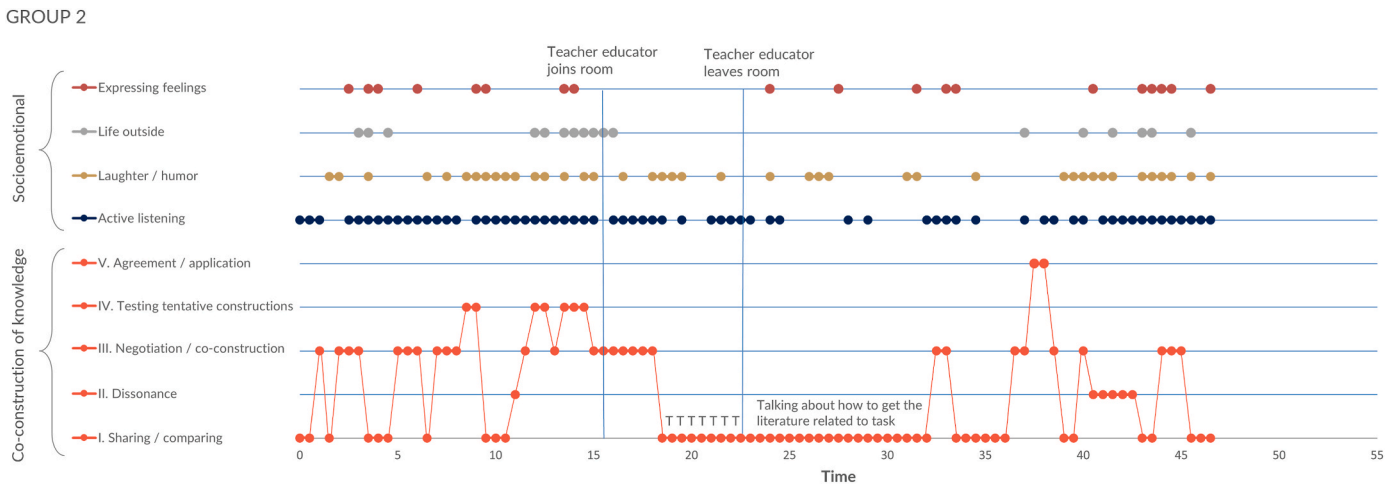


Fig. 7. Group2, second session.



Fig. 8. Nea, Emma, and Elias, and the teacher educator joining the breakout room.

to life outside occurred mostly at the level of sharing and comparing information (level I). In the beginning, while sharing experiences, Group2 also frequently expressed emotions. In other words, they shared personal experiences in an emotionally intensive atmosphere. Moreover, those moments were very attentive in terms of active listening.

This might lead to an idea that sharing subjective experiences can be motivating and emotion-filled but does not provoke higher-level thinking, at least directly. In the second session, as Group2 reached higher levels more often, they disclosed fewer experiences of life outside (Fig. 7), which might support that thought. However, in that session, the fewer life outside codes occurred more often at higher levels (especially IV). The definition of level IV supports this, as it includes testing the proposed synthesis against, for instance, personal experience or socio-cultural knowledge (Gunawardena et al., 1997). Furthermore, for the other group, Group1 (Figs. 4 and 6), life outside emerged at all the levels of knowledge construction—mostly I, but also many times with III, and marginally with II, IV, and V.

The first session by Group2 (Fig. 5) is interesting in terms of fluctuations of group level active listening. In the beginning, PSTs signaled active listening while sharing personal experiences. During and after the teacher educator's visit, active listening diminished. Again, toward the end, as the group's talk was mostly at the higher levels, there was more active listening. This reflects engagement on both the experiential level and the more conceptual level, or the phase of approaching a synthesis. Next, we illustrate how the teacher educator's visit influenced the processes of knowledge co-construction and socioemotional interaction.

5.3.2. "That was a lot of heavy stuff": how does the teacher educator's visit to the breakout room influence these processes?

In three out of four analyzed breakout rooms, Jody expressed dissonance, and during dissonance, there were less expressions of active listening. PSTs looked attentive but reserved. In some sessions, group level laughter was also diminished while Jody was present, but the changes were not as distinct as with listening. The second session by Group2 (Fig. 7) appeared different, as Jody did not bring out dissonance

but instead shared ideas (level I), and that resulted in considerably more active listening.

In the first session by Group1 (Nea, Emma, and Elias), we observed substantial changes both on knowledge construction and socioemotional facets during and after the teacher educator's (Jody's) visit to the breakout room (Fig. 4 between 15 and 30 min). Having joined the room, Jody silently observed for a moment. As the PSTs noticed Jody's presence, Nea advanced the conversation from an experiential level (I) to negotiating meaning (III) by asking "*so are we now choosing as a subtheme, how consumer behavior could be, like, brought up in schools and how that trend could be questioned?*" It might be that Jody's presence supported this synthesis. Then, Jody asked: "*would you like to tell me what the trend is that you want to address, I'll say in advance that I've been in all the other groups now sort of as a devil's advocate* [laughing], *throwing provocative statements, so, can you tell me what that trend is, that you would like to address?*" This question, in turn, elicited a summarization of agreement (V) as Nea and Emma explained that the group's focus had been on ecological sustainability. A similar pattern of Jody asking for a synthesis resulting in a summarization of agreement (V) also happened in their second session (Fig. 6).

Then, Jody brought dissonance (II) to the conversation; at this point, the PSTs' nonverbal interaction changed, and active listening diminished. In their statements, Jody quite multifacetedly expressed dissonance as described in one of the definitions by Gunawardena et al. (1997): restating one's position and supporting it by references to "experience, literature, formal data collected, or proposal of relevant metaphor or analogy to illustrate point of view" (p. 414). Jody restated their position as a "*devil's advocate*" and referred to experiences (recycling) and formal data (climate change assessment report) and suggested a metaphor or analogy (different ways of relating to disposable coffee cups) to demonstrate that the PSTs should move the discourse from the individual to the societal level. Those segments were the rare ones in which there were no socioemotional codings or only one PST slightly nodding.

Only Emma contributed in between Jody's statements, by saying "*yeah, or that material is the source of a good life, that kind of thinking* [laughter]" (III). Reacting to that, Jody brought forth another opposing view (II) of how material has become like dirt that people try to get rid of and how minimalism has become popular. Jody encouraged participation twice during the visit, but responses were scarce, namely "mmm" or "no." Before leaving, Jody humorously referred to having stated ideas "*without listening to anything you had said before,*" to which Emma smiled.

Immediately after the visit, Elias said, "*well that was a lot* …" and Nea continued "*yeah, a lot of heavy stuff,*" and they all laughed together. However, the students then reacted to Jody's dissonance by co-constructing and negotiating meaning (III) and stayed on that level for quite some time. Nea elaborated the coffee cup metaphor used by Jody (see excerpt of level III in Table 3). After the longer episode of mainly level III (between 22 and 27 min), the group expressed metacognitive statements (V), saying that Jody's points of views were good but extra broad, and that they "*somehow completely emptied my own thoughts* [laughing]." They noted that the individual level was much easier, and the societal level felt distant and difficult. They shared many laughs while addressing the difficult nature of the task.

Contrarily to the illustrative example above, Group2 only occasionally explicitly referred to Jody's ideas after the visit in their first session (Fig. 5). This might be because Jody did not ask Group2 for a synthesis, but just started expressing dissonance after listening for a while. Nevertheless, we suggest that Jody's dissonance may have been essential for Group2 as well, since directly after Jody's visit, Group2 moved from an experiential level (I) to negotiation and co-construction (III) (Fig. 5, between 15 and 18 min). They started building on each other's views and negotiating about how to guide students in the future with regard to digitalization. Later (at 26 min), a PST talked about how Jody's statements affected their thinking and said, "*this is a really broad topic, there's a lot more to this than I thought*" (V, metacognitive statement), similarly to Group1. In sum, the teacher educator's visit was significant, but it seems that dissonance was partly difficult to take in.

6. Discussion

The aim of this research was to investigate small group collaborative learning in synchronous video-based online teacher education. This study has been one of the first to thoroughly examine small groups' collaboration in synchronous online breakout sessions with video data. We analyzed collaboration for both the knowledge co-construction and socioemotional aspects. Overall, the results show that first-year preservice teachers engaged in complex processes of knowledge co-construction while addressing the relationship between megatrends and education. Simultaneously, they maintained a positive atmosphere in which humor and other socioemotional aspects were thoroughly present. Groups differed in their processes of knowledge co-construction and in their expressions of feelings and talk related to personal life. We observed no off-task talk related to personal experiences. The teacher educator's visits to the breakout rooms affected knowledge co-construction and socioemotional interaction.

6.1. Knowledge co-construction in synchronous video-based collaboration in TE

In all the analyzed breakout room situations, the majority of knowledge co-construction was on the level I of sharing information. In one video, there was equally as much of level I as of level III. Only a small percentage of talk reached the highest levels of co-construction of knowledge, namely testing proposed co-constructions (IV) or summarization, application, or metacognitive statements (V). The proportions of knowledge construction levels are somewhat similar to the results from asynchronous text-based learning environments (Lucas et al., 2014). However, in this study with synchronous video data, there was more evidence of negotiating meaning (III) than in most previous studies (De Wever et al., 2007; Lucas et al., 2014). Furthermore, many previous studies have reported only 0–4% of levels IV and V (Lucas et al., 2014), and in this study, the proportions were slightly higher. We discuss features that helped PSTs in achieving higher levels in Section 6.2.

Prior studies in university contexts have concluded that online collaboration does not often progress beyond the first phases of knowledge co-construction, in other words surface or individualistic level of sharing information (Ke & Xie, 2009; Lucas et al., 2014; Rourke & Kanuka, 2009). Thus, deep learning, including synthesizing ideas, applying knowledge, or self-reflection and metacognitive notions, does not emerge regularly online (Ke & Xie, 2009). In addition, in face-to-face settings, university students commonly fail to engage in argumentative or critical discussions, even while reasoning and collaborative learning are supported (Isohätälä et al., 2018). However, based on our findings, we argue that PSTs in this context, in an online breakout room with a challenging collaborative task, were able to negotiate their understanding multifacetedly and with relatively high quality. Surely, there were phases in which especially Group2 would have benefited from "rising above" (Scardamalia & Bereiter, 2010), by synthesizing shared views on the complex issues more often. Additionally, the courage to express more dissonance and developing abilities to do it without threatening others' faces, for example, by using hypothetical suggestions and other ego-reducing moves (Asterhan, 2013; Isohätälä et al., 2018), could further enhance PSTs' knowledge co-construction. Avoiding tension does not foster critical thinking and might reduce opportunities for learning (Isohätälä et al., 2018).

From a different perspective, it has been argued that it is a common pattern that socialization and information sharing turns are numerous, while higher levels of thinking are fewer in number (De Smet et al., 2008; Ke & Xie, 2009; Xie & Ke, 2011). When it comes to problem-solving, a similar idea is embedded in the quotation attributed to Einstein, stating that if he were to save the earth in an hour, he would

define the problem for 55 min and solve it within the last 5 min (Neumeier, 2012). For TE students to understand the positions each one is coming from, a larger amount of information sharing might be necessary (Lucas et al., 2014). We observed this as PSTs disclosed numerous details about their subjective experiences, mostly regarding school and university.

However, we also found that sharing personal experiences did not only occur at the lowest level of knowledge construction, but also, on many occasions, with levels III and IV (and marginally with levels II and V). First, this is consistent with the definition of level IV, which includes testing the proposed synthesis against personal or sociocultural knowledge (Gunawardena et al., 1997). Second, this partly contradicts Ke et al.'s (2011) conclusion that experiential statements, demonstrating identity presence, are not tuned toward summarizing different perspectives and, thus, higher levels of knowledge co-construction. Either way, we value experience-oriented talk as it fosters engagement, motivation, and trust (Ke et al., 2011) and, in TE, reflections about how to be a teacher. One can hardly talk about meaningful or dialogic learning without the personalization of learning (Arvaja & Hämäläinen, 2021).

6.2. Features supporting higher-level knowledge co-construction

We observed features that helped PSTs in achieving higher levels of knowledge co-construction: (1) the teacher educator's visits to the breakout rooms and intentional dissonance, (2) the teacher educator asking for a synthesis, (3) the open-ended, collaborative task and multiple guiding questions, and (4) socioemotional atmosphere, enabling relaxed humor, expressing anxiousness toward the difficulty of the task, and metacognitive statements. Next, we discuss these findings.

The teacher educator's visits and their dissonance affected the PSTs' knowledge construction and led to metacognitive statements. This finding is in line with studies indicating that an instructor's intervention is needed in online discussions to reach higher-level thinking (Hull & Saxon, 2009; Ke & Xie, 2011; Rovai, 2007). Furthermore, the significance of dissonance (Gunawardena et al., 1997) and questioning (e.g., Lorencová et al., 2019) has been widely acknowledged. As Scardamalia and Bereiter (2010) put it, ideas are enriched through comparison, distinction, and recombination, and "to understand an idea is to understand the ideas that surround it, including those that stand in contrast to it" (p. 9). In this study, the teacher educator restated their position as "*a devil's advocate*" while bringing dissonance. Interestingly, in the coding scheme by De Smet et al. (2008), the highest stage includes online tutors "playing devil's advocate," which is defined as creating doubts and counterarguments. This was literally manifested in our case study.

Although interventions by the teacher educator were beneficial, another perspective is that students appreciate an online instructor being active, but "not so much that it will overwhelm their ability to interact with others" (Larson et al., 2019; Tyrväinen et al., 2021, p. 134). We observed that the PSTs' participation and expressions of active listening diminished while the teacher educator expressed dissonance, and that dissonance was partly overwhelming for them. Also, it was not possible for the teacher educator to decide when to intervene and pose meaningful questions, an aspect which Hull and Saxon (2009) consider essential in learning through dialogue online. That was due to the nature of breakout rooms, where one has to join the space right in the middle of the discussion. Yet, the teacher educator sometimes asked for a synthesis of the previous conversation, and that both elicited higher-level synthesis and seemed to have a positive effect on the uptake of the dissonance after the visit.

The nature and complexity of the task has been identified as a key variable in small group collaboration in university settings (Onrubia & Engel, 2009; Schellens et al., 2007). The open-ended collaborative task regarding megatrends and education proved to be fruitful in terms of both knowledge construction and reflections about teacher identity. It dealt with complex real-world learning problems, which reinforce deeper-level learning and critical thinking (Heo et al., 2010; Lucas et al., 2014). The given guiding questions were open-ended, which is linked to higher-level knowledge construction (Ke & Xie, 2009). Next, we discuss the overall socioemotional space in the breakout rooms.

6.3. The socioemotional space

The socioemotional space in the breakout rooms facilitated addressing the complex connections between megatrends and education, and this was visible, for example, in tension–relaxation (Andriessen et al., 2011) and in the directness in which the PSTs expressed anxiousness toward the difficult task (see Isohätälä et al., 2020). Also, the PSTs seemed to be motivated toward both sharing their experiences and co-creating new ideas. The results given in Section 5.3 shed light on how various socioemotional aspects evolved simultaneously with knowledge co-construction.

Interestingly, we observed no off-task sharing of personal life in the analyzed breakout rooms. This further supports the idea that in online environments, off-task communication is often neglected (Kreijns et al., 2003). This might lead to issues in creating a learning community, since off-task communication can be an essential part of intersubjectivity (Vygotsky, 1978), which builds relations between participants (García et al., 2020; Jones et al., 2022). However, identities and self-disclosure were present in task-related interactions. This is similar to Ke et al.'s (2011) finding indicating that "identity presence emerges with relationship-based learning interactions rather than interactions solely for the purpose of socializing" (p. 366). They suggest that such learning interactions can be supported by encouraging deep sharing of experiences and values. Questions related to values could have further facilitated this in the breakout rooms.

The online space made it possible to participate without a web-camera, which has previously led to problems with reciprocity among university students (Oittinen et al., 2022). In our study, the two students without a web-camera participated less in knowledge construction and active listening, yet the same was observed with another student using a web-camera. Individual differences are large, but the absence of a video connection makes it easier not to participate and more difficult for others to observe the emotional stance or attentiveness. On the other hand, there is some laboratory evidence (Tomprou et al., 2021) that audio-only communication can enhance pairs' equality of turns and, given that, help reach higher collective intelligence, as measured in a computer-mediated test. However, solving real-life collaborative tasks requires complex meaning-making in which the social space is starkly different to that of a laboratory setting or assessment by a test. Our study shows that when a video connection is not possible, the use of the microphone for back-channeling ("mmm," "yeah") can be essential (Section 5.2). This is contrary to the convention that encourages participants to mute their microphones in video-based meetings, even within a small group.

We believe that the observed relaxed and humorous atmosphere was partly due to the PSTs having worked together in a face-to-face setting previously. Knowing each other and creating a safe atmosphere where one can participate without the risk of being criticized or ignored are essential when striving to foster high-level knowledge construction (Lucas et al., 2014). Students were well familiarized with each other; a condition that may not have been possible in an online-only mode, as online environments eliminate many physical cues, reducing psychological proximity and familiarity between participants and potentially resulting in lower quality learning (e.g., Sherblom, 2010).

However, we also observed a lack of participation or low-level participation. Joint participation does not have to be totally continuous but sustained enough (Isohätälä et al., 2018). The PSTs could have encouraged each other's participation more often to help tackle the issues in video-based collaboration, for example, the lack of a web-camera. Although we concluded that the PSTs were able to engage in high-quality knowledge co-construction, we highlight the importance

of considering how online education, especially during crises, affects engagement, relatedness, and study burnout (Salmela-Aro et al., 2022). Our results reaffirm that in online settings, synchronous discussions are of value since they most closely resemble face-to-face interaction (Reinholz et al., 2020) and that perception of presence can be increased with a video connection (Clark et al., 2015; Oittinen et al., 2022).

Finally, although we addressed collaborative learning through defining lower and higher levels of knowledge co-construction, we appreciate the idea that intersubjectivity in collaboration starts from seeing the value of others, "appropriating different voices, really 'hearing' one another's points without rejecting one's own or other's differing voices" (Arvaja & Hämäläinen, 2021, p. 2). This was enabled in the socioemotional space between peer pre-service teachers.

6.4. Limitations and future perspectives

Despite exploring some regularities in the PSTs' collaborative learning, we acknowledge that the small sample limits the generalization of our results. However, the fine-grained analysis illustrates aspects of synchronous collaboration in breakout sessions that are largely uninvestigated. Also, analyzing interaction in real-life case groups means smaller datasets, since a fine-grained analysis of interaction and nonverbal communication is time consuming (Jones et al., 2021). This design could be adopted in larger-scale studies, multi-case study designs or other contexts. Other perspectives of socioemotional interaction could be examined, such as empathy (Hod et al., 2020). Active listening could be more thoroughly analyzed (Gordon, 2003; McNaughton et al., 2008) since we focused on attunement through back-channeling and nodding. However, the way PSTs built on each other's perspectives in knowledge construction provides a further insight into active listening. Moreover, the processes of knowledge construction could be analyzed using other methods, further analyzing the knowledge content, or considering additional aspects, such as teacher identity.

We drew conclusions of the features that supported PSTs' higher-level, critical thinking together, and about the ways in which socio-cognitive and socioemotional spaces were intertwined. Given the qualitative nature of our study, we cannot propose a causal relationship between the different facets of learning. We cannot be sure whether the socioemotional atmosphere influenced knowledge co-construction, or whether the stimulating experience of sharing ideas resulted in, e.g., laughter and humor. Future studies could further examine the relations between social, emotional, and cognitive facets in synchronous online collaborative learning, and how these relations influence higher-level knowledge construction. Additionally, different tasks could be investigated. Our results on knowledge co-construction might have been different had not the assignment been open-ended, since task complexity is a key aspect (Schellens et al., 2007).

We used observational methods in this study. Content and interaction analysis could be triangulated with self-reporting and learning outcome measures (Jones et al., 2021; Ke & Xie, 2009). Finally, we acknowledge that the larger proportions of high-level knowledge construction are partly due to our focus being on the group level, meaning that we assigned the highest level by the small group to each 30-s unit of analysis. This enabled analyzing and visualizing the overall quality of joint thinking and, as Barron (2003) notes, keeping the group as the primary unit of analysis provides new insights into how and why some discussions are more beneficial for learning than others.

7. Conclusion

The findings shed light on how knowledge co-construction and socioemotional activities are intertwined, and how to support the collaborative learning of future teachers. Theoretically, our study adds to the understanding of how online small group collaboration differs from face-to-face contexts, and what are the affordances of online breakout rooms for learning. The results also advance the field in simultaneously addressing both the small group and individual levels. Methodologically, our study gives insight on how the tools used in analyzing face-to-face and asynchronous online collaborative learning can be applied to synchronous online settings.

Implications such as favorable scaffolding strategies that promote synthesis and provide possibilities to practice critical thinking and negotiation will help to design high-quality online, blended, and hybrid TE. During their studies, PSTs learn not only *about* educational processes, but also *through* those processes. If collaborative learning is well designed and scaffolded in TE, it has the potential to make a difference in how future teachers adopt collaborative learning designs in their classrooms.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this.

Data availability

The authors do not have permission to share data.

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